1-16-1969

Service Propulsion System (SPS) - Malfunction Symptoms 1 - 16

National Aeronatics and Space Administration (NASA)

OPTIONAL FORM NO. 10
MAY 1962 EDITION
GSA FPMR (41 CFR) 101-11.6

UNITED STATES GOVERNMENT

Memorandum

COPY TO J. Swigert CF22/ Baker 1-16-69

J. SMOTHERMON
L. DEWOLF
G. STEELE
E. DEMENT
BAKER (Lost)

TO : CF/Chief, Flight Crew Support Division

DATE: JAN 15 1969

FROM : PF/Chief, CSM Project Engineering Division

In reply refer to: PF2-0/42-69

SUBJECT: Changes to Apollo Operations Handbook to support Spacecraft 104

The following changes to the AOH (Apollo Operations Handbook) should be made to support the S/C 104 mission:

a. In the event the CO_2 sensor causes a master alarm to activate during the mission, the CO_2 sensor is to be deactivated by pulling circuit breaker number thirty-four on panel 5. This procedure change is being made because of marginal operation of the CO_2 sensor, and because the sensor is not mandatory for the S/C 104 mission. Coincident with the change to the AOH, the CO_2 measurement priority in the Flight Mission Rules is downgraded from "Mandatory" to "Highly Desirable".

b. Previous direction for positioning of RCS solinoid valves, which are closed from approximately T-20 minutes on launch day, is rescinded. The RCS solinoid valve shall be open at approximately T-20 minutes on launch day. Appropriate changes should be made to the AOH to reflect this change.

ORIGINAL SIGNED BY:
AARON COHEN

Aaron Cohen

cc:
CF22/J. L. Baker
PA/G. M. Low
PA/K. S. Kleinknecht
PD/D. Segna

PF2:HFRees:lsb 1/14/69

will incorporated

CSM 2462 initiated to CLOSE RCS valves in response to G. Low, Memo PA8-12-K9, dated 12-19-68. This memo reversed by Low, memo PA9-1-10, dated 1-9-69, as well as this A. Cohen memo.

CSM 2462 disapproved 1-14-69 - subject valves remain OPEN at launch in AOH. J. L. Baker

NOTE: CSM FOD schematic of Power Distribution Matrix Main Bus F.9 3.2 dated Dec. 19, 1968, appears erroneous and incompatible with ECS schematics (same handbook) - i.e., Pwr Distribution Fig 3.2 indicate MN B PWR (CB35) powers CO_2 Partial Pressure Sensor.

Because CO_2 HI relates to a failure (sensor or otherwise) the above affects CSM Malfunction Procedure ECS Symptom 12 only - no normal or backup procedures. By pulling CB34, redundant power is removed from the following instrumentation (ref. FOD schematics):

1. It was recommended to H. Reese that the aforementioned Malf. Proc. be revised - but should reflect a crew option rather than a requirement. It is intended to add a remark to the Malf. Proc. to the effect that if the crew elects to extinguish the light - power will be removed from the CO_2 meter and redundant power will be removed from the above listed instrumentation by opening CB31. Changing the Malf. Proc. has been discussed with J. Swigert. H. Reese concurs with FCSD recommended action per telecon, 1-16-69. J. L. Baker

Gly evap steam press sensor
O_2 supply manif press sensor
Cabin press sensor
O_2 Flow rate sensor

1-16-69

add 1

SYMPTOM	PROCEDURE	REMARKS

SYMPTOM

1 SPS PRESS — YELLOW
Light on if:
FUEL or OXID PRESS
> 200 psia
< 157 psia

1a FUEL AND/OR OXID PRESS HIGH
>195 psi

1b FUEL AND/OR OXID PRESS LOW
<170 psi

1c FUEL AND OXID ΔP >20 PSI

PROCEDURE

1 FUEL and OXID PRESS agree? — YES → NORMAL

NO → 19 SPS FUEL and OXID PRESS? — ONE HIGH → 20 SC thrusting? — NO → 21 MFSN verifies press high? — YES → 22 HEAT LEAK INTO SYS (5, 2)

20 SC thrusting? — YES → 21 MFSN verifies press high? — NO

ONE LOW → 23 SC thrusting? — NO → 24 MSFN verifies press low? (5) — NO → 25 INSTRUMENTATION FAILURE

23 SC thrusting? — YES → 26 Burn mission critical? — NO → 33 • ΔV THRUST (2) - OFF

26 Burn mission critical? — YES → 29 • Continue burn (3, 5)

24 MSFN verifies press low? — YES → 27 Press decr? — YES → Warning: Except in emergency, do not cycle He vlvs - possibility of tk rupture → 28 PRPLNT LEAK OR He LEAK (6)

27 Press decr? — NO → 30 Decr occur during engine operation? — YES → 31 Attempt manual He repress; • SPS He vlv (both) - ON; Press incr? — YES → 32 RESTRICTED He LINE (3, 7)

30 Decr occur during engine operation? — NO → 34 COLD SOAK PROBLEM (2)

31 Press incr? — NO → 35 He SYS COMPLETELY CLOSED (3, 7)

BOTH HIGH → 3 • SPS He VLV (both) - OFF; SC thrusting? — NO → 4 HEAT SOAK INTO PRPLNT TK (2)

SC thrusting? — YES → 5 Burn mission critical? — YES → 6 • Continue burn (3)

5 Burn mission critical? — NO → 7 • ΔV THRUST (2) - OFF → 8 DUAL He REGULATORS FAILED OPEN (4)

BOTH LOW → 9 SC thrusting? — NO → 10 COLD SOAK PROBLEM (2)

9 SC thrusting? — YES → 11 Both He tb's bp? — YES → 12 • SPS He VLV (both) - ON; Both tb's bp? — NO → 13 AUTO CONT OF He VLV FAILED (X)

12 • SPS He VLV (both) - ON; Both tb's bp? — YES → 15 DUAL He VLVS FAILED CLOSED (3)

11 Both He tb's bp? — NO → 14 FAILURE IN He SYS → 16 Burn mission critical? — YES → 17 • Continue burn (3)

16 Burn mission critical? — NO → 18 • ΔV THRUST (2) - OFF → 31

FUEL/OX PRES = 170psi.

NORMAL → 2 C/W FAILURE

REMARKS

(1) Normal operating press is 170 - 195 psia. MSFN will use fuel and oxid telemetered press data to backup onboard indications.

(2) Attempt temp cont by reorienting SC if possible.

(3) Engine chugging may occur if SPS Pc is < 60 psi. Conserve propellant tanks pressurized to 185 psi.

(4) Control prplnt press between 175 and 185 psi by manual actuation of He sw. Flow through failed regs will exceed the capability of the relief vlv.

add to (2)

a. Fuel & Oxid press high — orient —X axis toward deep space

b. Fuel Press high — orient —Z-Y quadrant toward deep space

c. Ox press high — Orient +Y, +Z quadrant toward deep space

KSC change 12/13

(5) **Caution** ΔP between FUEL and OXID PRESS should not exceed 20 psi during a burn. Degraded performance, rough combustion, and/or engine failure may result.

(X) Open and close He values manually for each burn

(6) Prior to emergency SPS operation, manually repressurize propellant tanks.

(7) All subsequent SPS burns should be made with SPS He VLV (both) - OFF to minimize ΔP between fuel and oxidizer.

NA — notes should be renumbered from (5) on to make room for (X)

Red = 103 KSC change 12/13/68 OK?

discuss

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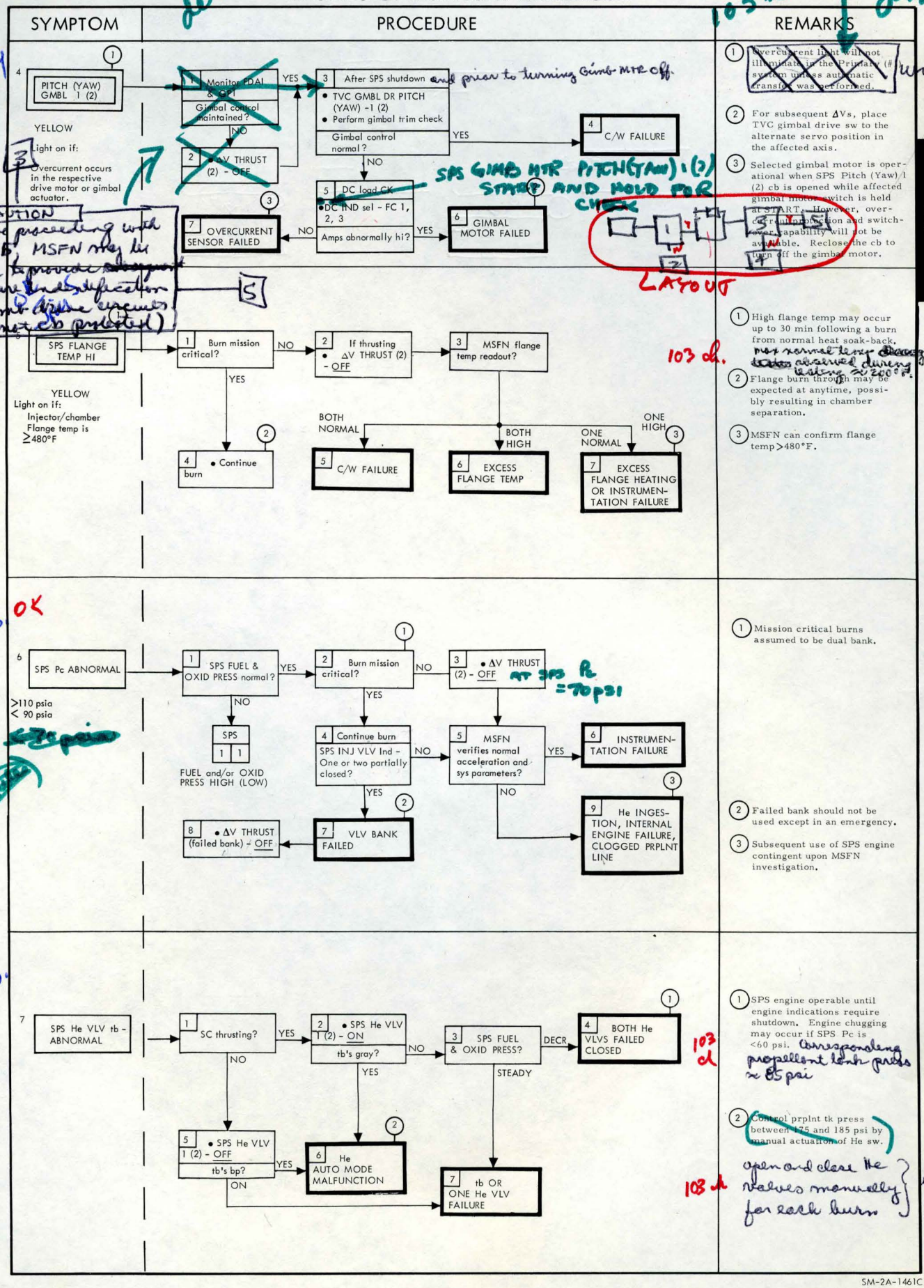
SYMPTOM	PROCEDURE	REMARKS
2 PREMATURE SPS SHUTDOWN 2a NO SPS IGNITION	1 SPS THRUST lt on? YES → 2 Dual bank operation? YES → 3 SPS - SCS CIRCUITRY FAILED NO → 4 All SPS INJ VLVS closed? YES → 5 cb SPS PILOT VLV A MNA (B MNB) open? YES → 7 ENG VLV CIRCUITRY SHORTED NO → 6 VLV PAIR FAILED CLOSED → 9 •ΔV THRUST A (B) - OFF 8 Burn mission critical? NO → 11 SC control? SCS or THC CW / CMC YES → 10 Reignite engine CMC Burn • Discontinue ullage If FL V97 N40 (R40) • PRO - if thrust back on, or • Reorient to thrusting attitude • Reinitiate ullage • ENTR when FL V99 N40 • PRO or • SC CONT - SCS • Initiate ullage • THRUST ON pb - push or SPS THRUST - DIR ON (lock) SCS Burn • Continue/Initiate ullage • THRUST ON pb - push or SPS THRUST - DIR ON (lock) • Terminate burn on ΔV or time 11 SC control? CMC → 13 Output CHAN check • V01 N10E 11E •ΔV THRUST (2) - OFF • Recycle to IGN in P40 1 in A of R1? YES → 15 WIRING OR SCS THRUST LOGIC FAILED NO → 16 CMC INTERNAL FAILURE → G&N SSR-1 CMC SELF TEST 11 SC control? NO → 12 ΔV test • Perform EMS ΔV test Test ok? NO → 14 ΔV COUNTER ZERO SENSE FAILED YES → 15 WIRING OR SCS THRUST LOGIC FAILED	(1) If CMC burn, SPS THRUST ON lt will be on for only a few seconds after SPS shutdown. (2) SPS functions lost. (3) Use alternate SPS bank for future ΔV's. (4) Engine restart should not be attempted within 5 seconds from initial ignition in order to avoid undesirable helium pressure excursions. (5) Not possible to distinguish between these two failures.
3 SPS ENG DOES NOT SHUT DOWN AUTOMATICALLY	1 → 2 → 3 → 4 → 5 → 6 → 7 → 8 → 11 → 10 → 9 → 12 RANGE/ΔV IND ABN IN TEST	(1) Assumes SPS ENG has been shut down with the ΔV thrust switches. (2) Subsequent ΔV's should be performed on unaffected bank (failed bank can be determined by MSFN from TLM and by crew from SPS INJ VLV ind). Failed bank may be used in an emergency by placing associated ΔV THRUST sw ON at T IGN.



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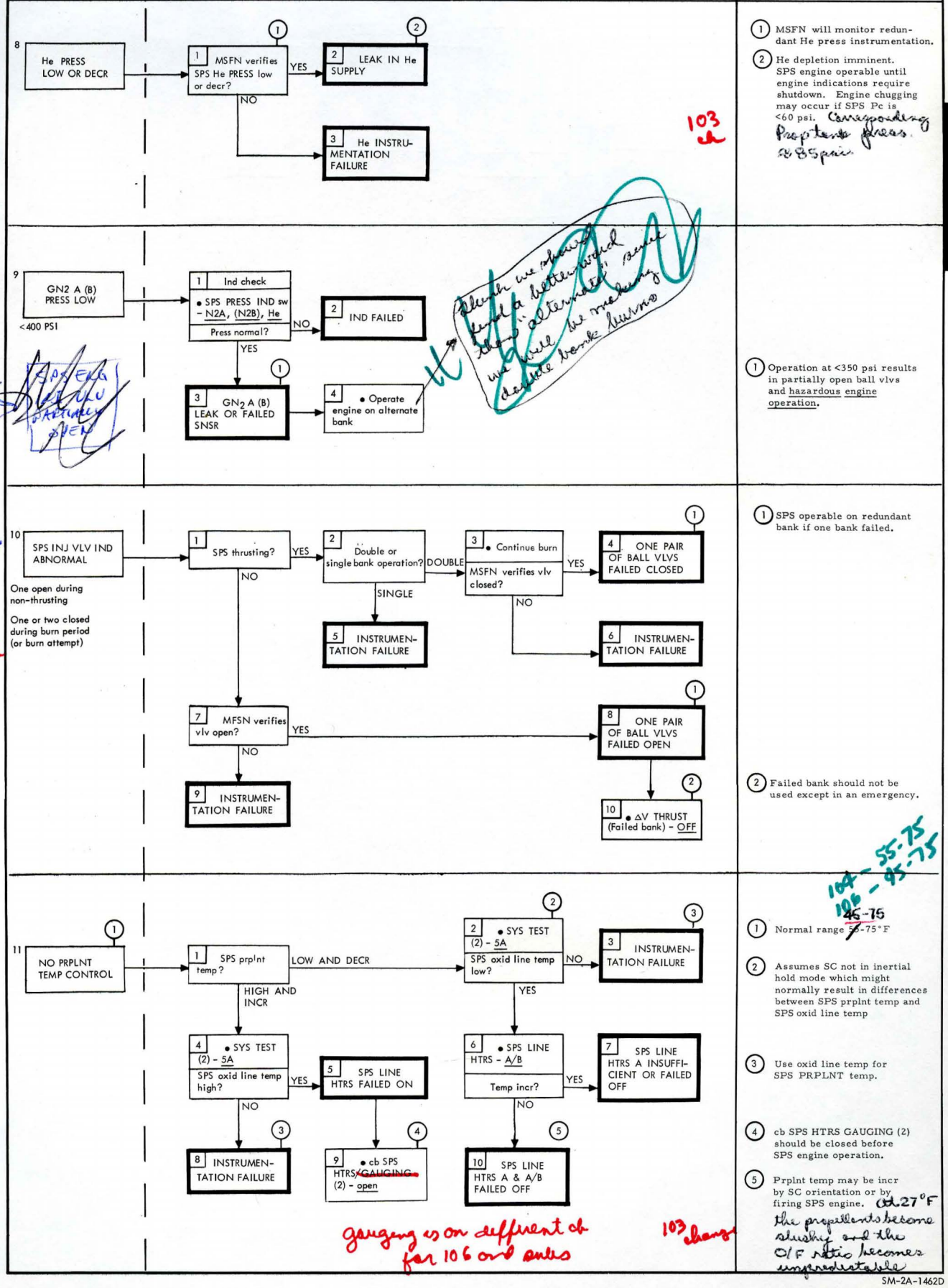

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SYMPTOM	PROCEDURE	REMARKS
12 NO RESPONSE OF SPS OXID VLV tb DURING FLOW ADJUST (OXID FLOW VLV PRIM - PRIM)	1 • OXID FLOW VLV INCR - NORM after 5 seconds: • OXID FLOW VLV PRIM - SEC • OXID FLOW VLV INCR - INCR (DECR) OXID FLOW VLV tb correct? YES → 2 PRIM OXID FLOW VLV FAILED NO → 3 OXID FLOW VLV tb FAILED 4 • OXID FLOW VLV INCR - NORM after 5 seconds: • OXID FLOW VLV PRIM - PRIM • OXID FLOW VLV INCR sw - as desired	(1) The OXID FLOW VLV INCR sw cannot operate unless power is applied through a THRUST ON signal or through the SPS QTY TEST sw. If flow vlv position was changed by the SPS QTY TEST sw, fuel and oxid quantity readouts must be returned to the original values. (2) Sec vlv has sufficient range to compensate for prim vlv failure in any position and still provide vlv openings for INCR, NORM or DECR oxid flow. (3) The Secondary sliding gate vlv must be in the nominal flow position (rather than INCR or DECR) before switching to the PRIM OXID FLOW VLV or misalignment of the secondary vlv could make the primary vlv inoperative.
13 SPS OXID UNBAL IND ERRATIC OR PEGGED	1 • PUG MODE - AUX OXID UNBAL ind normal? NO → 2 UNBAL ind check • SPS QTY TEST - 1 for 10 sec, then 2 for 10 sec OXID UNBAL ind norm? NO → 3 OXID UNBAL Ind FAILED → 4 Return to normal PUG mode • PUG MODE - PRIM • Perform qty test • PUG MODE - NORM YES → 5 PRIM UNBAL SYS FAILED	(1) Assumes qty indicating sys normal. (2) Assumes SC is still thrusting. If thrust has terminated, proceed with step 2. (3) Actuation of SPS QTY TEST sw here will realign digital display to prim sys.
14 SPS OXID (FUEL) QTY IND READOUT ABNORMAL	1 • PUG MODE - AUX % FUEL (% OXID) readout normal? YES → 2 Prim qty test • SPS QTY TEST - 1 • Incr % oxid by 5.0% % Fuel incr by 4±1%? YES → 3 CAPACITANCE PROBE FAILED NO → 5 PRIM SYS SERVO AMP FAILED → 6 Use aux sys • PUG MODE - AUX NO → 4 Aux qty test • SPS QTY TEST - 1 • Incr % oxid by 5.0% % Fuel incr by 5±1%? YES → 2 NO → 7 DISPLAY FAILED	(1) Assumes SC is still thrusting. If thrusting terminated before step 1 is complete, proceed to step 4. (2) Complete thrusting prior to QTY TEST. (3) MSFN must now supply any prplnt quantity data.

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SYMPTOM	PROCEDURE	REMARKS

15 SPS PU SNSR — YELLOW

Light on if:

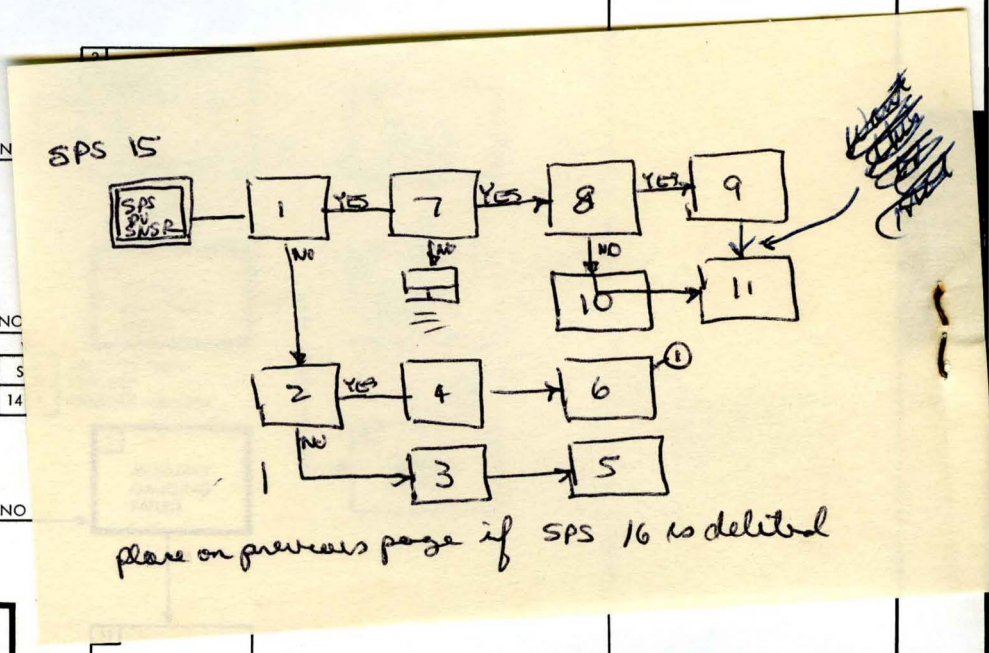
Unbalance in Propellants >600 lbs or 90% of critical unbalance
or
Disagreement between Primary & Auxiliary sensors > 3% for fuel or oxidizer

1 SPS OXID UNBAL ind — Within limits? — NO / YES

7 SPS OXID & FUEL QTY ind — Normal? — NO / YES

8 • PUG MODE - AUX
• SPS OXID & FUEL QTY ind — Normal? — NO / YES

10 PUGS MALFUNCTION DETECTION CIRCUITRY OR C/W CIRCUITRY FAILURE → • PUG MODE - PRIM



place on previous page if SPS 16 is deleted

16 ROUGH ECO — YELLOW

MASTER ALARM — RED

Lights & alarm tone if:
Vibration level of 180 g's peak-to-peak for 50-90 msec, or 360 g's peak-to-peak for 30-70 msec

1 Manual ECO
• ΔV THRUST (2) - OFF
• MASTER ALARM pb - push
Burn mission critical? — NO / YES

2 MSFN verifies abnormal eng operation? — NO → 3 POSSIBLE COMBUSTION INSTABILITY OR INSTRUMENTATION FAILURE; YES → 4 SPS COMBUSTION INSTABILITY (1)

5 Attempt burn completion (2)

CMC Burn
• ΔV THRUST (2) - NORMAL
• PRO
or
• ENTR
When FL V99 N40
• ΔV THRUST (2) - NORMAL
• PRO

SCS Burn
• ΔV THRUST (2) - NORMAL
• THC - +X or DIR ULL pb - push hold
• THRUST ON pb - push or SPS THRUST - DIR ON (lock)
• Terminate burn on ΔV or time

(1) SPS operability dependent upon subsequent investigation.

(2) Engine restart should not be attempted within 5 seconds from initial ignition in order to avoid undesirable helium pressure excursions.

This box should be identical to step 10 of SPS #2

In order to get the light one FCSM must be at A or B this will close one set of bell values and the switch should be placed at reset/overreid to give double bank open for mission critical burns

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SYMPTOM	PROCEDURE	REMARKS

15 SPS PU SNSR — YELLOW

Light on if:
Unbalance in Propellants ≥600 lbs or 90% of critical unbalance
or
Disagreement between Primary & Auxiliary sensors > 3% for fuel or oxidizer

1. SPS OXID UNBAL ind — Within limits? — NO → 2. • PUG MODE - AUX • SPS OXID UNBAL ind — Within limits? — NO → 3. PROPELLANT UNBALANCE EXCESSIVE → 5. • PUG MODE - NORM
YES → 4. PRIMARY UNBALANCE FAILED → 6. Continue in aux mode (1)

7. SPS OXID & FUEL QTY ind — Normal? — NO → SPS 14 1 SPS OXID (FUEL) QTY IND READOUT ABNORM
YES → 8. • PUG MODE - AUX • SPS OXID & FUEL QTY ind — Normal? — NO → 9. AUXILIARY GAUGING FAILED
YES → 10. PUGS MALFUNCTION DETECTION CIRCUITRY OR C/W CIRCUITRY FAILURE → 11. • PUG MODE - PRIM

(1) Telemetry will provide total quantities from auxiliary system, and sump tank quantities from primary system.

16 ROUGH ECO — YELLOW
MASTER ALARM — RED

Lights & alarm tone if:
Vibration level of 180 g's peak-to-peak for 50-90 msec, or 360 g's peak-to-peak for 30-70 msec

1. Manual ECO • ΔV THRUST (2) - OFF • MASTER ALARM pb - push — Burn mission critical? — NO → 2. MSFN verifies abnormal eng operation? — NO → 3. POSSIBLE COMBUSTION INSTABILITY OR INSTRUMENTATION FAILURE
YES → 4. SPS COMBUSTION INSTABILITY (1)
YES → (2) 5. Attempt burn completion
• CMC Burn ΔV THRUST (2) - NORMAL • PRO or • ENTR
When FL V99 N40 • ΔV THRUST (2) - NORMAL • PRO
SCS Burn • ΔV THRUST (2) - NORMAL • THC - +X or DIR ULL pb - push hold • THRUST ON pb - push or SPS THRUST - DIR ON (lock) • Terminate burn on ΔV or time

(1) SPS operability dependent upon subsequent investigation.

(2) Engine restart should not be attempted within 5 seconds from initial ignition in order to avoid undesirable helium pressure excursions.

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